Globelics

Beyond the 'Creation' Side of Innovation: Outcomes of Innovative Capability Building in Latecomer Process-intensive Industries: Evidence from Brazil's Pulp and Paper[1]

Paulo N. Figueiredo and Saulo Gomes[2]

Abstract

Despite the proliferation of studies on the creation of firms' capabilities (learning) and on the nature of capabilities (as sources of firms' competitive advantage), especially from the early 1990s, there have been only a few studies addressing some of the 'outcomes' of learning and capabilities for the improvement in firms' performance. Additionally, even in terms of capability studies, especially in the context of emerging economies, at both macro-level most of them, with a few exceptions, have focused on innovative capability in firms and industries that are based on 'high-tech' and 'assembled products' firms and industries. These are deemed as only possible route for developing countries to achieve international industrial leadership. And most of these studies focus on capabilities that permit firms to move towards and/or catch up with the *production* and/or *innovation* frontier led by incumbent firms in early industrialised countries. Thus we know very little about capability building beyond catching-up and their implications for performance improvement. This paper examines processes of firm-level capability accumulation in the pulp and paper industries, across policy regimes in Brazil, during the 1950-2006 period. It goes further to examine the extent to which the accumulation of technological capability has improved indicators of technical (including environmental) to economic indicators. The study found a positive association (not causality) between efforts on innovative capability building and improvement on different types of process and environment performance indicators in the researched pulp and paper firms. Improvements on these indicators were associated with innovation efforts to achieve operational, market and economic performance improvement. The evidence shows that environment performance improvement was associated with innovative capability building. As a result, the findings show that the paths by which latecomers firms can achieve international leadership in process-intensive (and natural resources related industries) by building innovative capability beyond catching-up to overtake early innovators. On the basis of the building of such

[1] This paper is part of a broader research project carried out within the Research Programme on Technological Learning and Industrial Innovation in Brazil at the Brazilian School of Public and Business Administration (EBAPE), Getulio Vargas Foundation (FGV). Such project investigated the pattern of firm-level technological capability accumulation, sources of capability (intra- and inter-organisational learning mechanisms, and implications for techno-economic performance improvement in the forestry, pulp and paper industries under different industrial regimes in Brazil (1950-2006). This large research project was sponsored by the National Scientific and Technological Council in Brazil (CNPq), the Brazilian Association of Pulp and Paper (Bracelpa) and FGV.

[2] Brazilian School of Public and Business Administration (EBAPE), Getulio Vargas Foundation (FGV)
Email: – paulo.figueiredo@fgv.btr; Saulo Gomes – sgomes@fgv.br

innovative capabilities, firms can improve operational and environment performance indicators. Thus, it is not possible to design corporate strategies and government policies for operational and, mainly, environment performance improvement without understanding and tackling the issue of firm-level innovative capability building, especially the nature, direction and rate of innovative capability building within firms. Otherwise, issues like ‘corporate social responsibility’ and ‘environmental sustainability’ risk being confined to opportunistic rhetoric.

1. Introduction

During the past decades, and especially from the early 1990s, there has been a proliferation of studies on innovation capabilities as sources of firms’ superior performance. This has been particularly emphasised in studies focusing on world technologically leading firms in early industrialised countries (e.g. Prahalad and Hamel, 1990; Teece et al., 1990; Iansiti and Clark, 1994; Iansiti, 1998; Teece, 2007). Some of these studies also examined the sources of such capabilities such as knowledge-building activities (Leornard-Barton, 1995) and other types of learning activities (Malerba, 1992; von Hippel and Tyre, 1995; Boisot, 1998). Within the context of firms operating in late-industrialising or emerging economies – latecomer firms, in which our interest and focus of this paper falls, from the mid-1990s here has been a new generation of studies examining firms capability building and the underlying learning processes (e.g. Hobday, 1995; Kim, 1997, 1998; Dutrénit, 2000).

Despite the proliferation of studies on the creation of firms’ capabilities (learning) and on the nature of capabilities (as sources of firms’ competitive advantage), especially from the early 1990s, there have been only a few studies addressing some of the ‘outcomes’ of learning and capabilities for the improvement in firms’ performance. Indeed, over the past two decades the late-industrialising literature – and also the strategic management and innovation literature – have made more efforts on the investigation of innovative capability itself and its <u>creation</u> or <u>inputs</u> (learning) and much less efforts on the examination of their implications or <u>outcomes</u> for performance improvement (other than innovation performance) like technical/operational, economic and financial, environmental and social. Consequently, there are only a few exceptions that have looked at these issues from an explicit and systematic manner.

Additionally, even in terms of capability studies, especially in the context of emerging economies, especially from the early 1990s, at both macro-level (e.g. Lall, 1994; 2003) and firm-level (e.g. Hobday, 1995; Kim, 1997, 1998; Hwang, 1998; Ariffin, 2000; Figueiredo, 2001; Marcelle, 2005; Tsekouras, 2006), most of them, with a few exceptions, have focused, on innovative capability in firms and industries that are based on ‘high-tech’ and ‘assembled products’ firms and industries as what seems to be the only possible route for developing countries to achieve international industrial leadership. Secondly, most of these studies focus on capabilities permit firms to move towards and/or catch up with the production and/or innovation frontier led by incumbent firms in early industrialised countries.

A few respected studies sought to overcome such shortcoming (e.g. Dutrénit, 2000; Amsden and Tschang, 2003; Hobday et al., 2005; Dantas, 2006). However, studies examining latecomer firms’ capability building process, across different policy regimes, that lead them not only to catching-up, but also permitting that move further to overtake earlier incumbent innovators, especially in process-intensive and natural resource-related industries, are largely missing in the emerging countries literature on innovation. Put differently, studies that departure from the 'ICT paradigm' to explore the extent to which technological innovation capability contribute to industrial progress in countries endowed with natural resources and/or whose large part of their economy is based on process-intensive industries, are badly needed.

This paper seeks to contribute to filling that gap. Drawing on first-hand qualitative and quantitative empirical evidence gathered through extensive fieldwork, this paper examines the technological capability building paths and their implications for operational and environment performance improvement in a set of nine pulp mills and 11 paper mills in Brazil during the 1950-2006 period. This paper is organized as follows. Section 2 reviews the study background. The analytical framework against which the empirical evidence is examined is presented in Section 3. The empirical setting in which the study was developed is outlined in Section 4, whereas the research methods are described in Section 5. Empirical evidence and discussions presented in Section 6, while Section 7 presents the paper conclusions.

2. Study Background

Notwithstanding the merits of the studies from the 1990s of latecomer firms' capability building, most of them have focused on the manner and, to some extent, the rate at which, firms have accumulated their capabilities to *catch up with* incumbents in terms of both *production* and *innovative* capabilities. However, there are fairly rare studies that sought to examine successful and failed experiences of firms that went through a transition process from latecomers into internationally leading innovative companies (see, for instance, Dutrénit, 2000; Hobday et al., 2004; Dantas and Bell, 2006).

Indeed, over the past decades, most of the academic studies and policy analyses and recommendations related to industrial development in late-industrialising countries have focused on the role of high-technology industries (mainly product-based) and 'high-tech content' exports (product-based) in achieving economic progress (e.g. Lall, 1992, 2003; Narula, 2002; Lall et al., 2004; Rasiah, 2008). Such view seems to be heavily influenced by the information and communications technology (ICT) paradigm, on the one hand, and on the successful experience of Southeast Asian countries, on the other hand (Bell and van Dijk, 2003; Perez, 2007).

Such overemphasis on micro-electronics related industries seems to overlook the innovative activities in process-intensive (natural resource related) industries and their role in contributing to industrial and economic progresses in developing countries. The latter are especially important to African and Latin American countries and Russia that are endowed with rich natural resources, but latecomers (see, for instance, *The Economist*, March 15th 2008). Previous studies have pointed to the importance of such sectors to industrial growth in different countries (e.g. Chenery et al., 1998) and their role in supporting and fostering industrial progress in developing countries (Bell & Pavitt, 1993, 1995; Bell et al., 1995; von Tunzelmann, 1996). However, process-intensive industries (based on natural resources), especially in developing countries, tend to be deemed as merely 'mature sectors', producers of 'commodities' with very little (if any) involvement in innovative technological activity (see, for instance, Cimoli & Katz, 2003).

Additionally, the latecomer literature lacks studies that examine the dynamics (speed) of capability building processes from industry and firm-level standpoints leading to either catching-up or overtaking (Bell, 2006; Figueiredo, 2007), especially across different policy regimes especially over time. This is important to capture, for instance, the nuances of the implications of changes from the import substitution industrialisation (ISI) policy into an open and outward-looking economy and avoid polarised explanations.

In relation to capability related empirical studies in latecomer process-intensive industries, especially in pulp and paper, about 20 years ago, Scott-Kemmis' (1988) study of Brazil's pulp and paper (1940-70) found a positive role played by different learning mechanisms and government policy in building firms' capabilities. Moving further and based on an inter-country comparison, Tremblay (1994) found a positive correlation between technical change, productivity growth and technological capability when the latter was embodied in aspects of organisational systems, regardless of being in India or Canada, while Dalcomuni (1997) emphasised the importance of firms' internal capabilities (mainly R&D), as opposed to market pressures only, to respond to environmental regulations and to foster 'green innovation'. However, these studies did not examine firm-level capability accumulation. An important, advance was made in van Dijk and Bell's (2003, 2007) that, from a country-level perspective, examined the Indonesia's case of accelerated growth rates in physical capital accumulation, but, contrary to Korea, limited innovative capability building.

With respect to the implications of learning and innovative capability for performance, it has been argued in Dosi (1985) that there is a permanent existence of asymmetries between firms in terms of their operational performance. Firms can be generally ranked as 'better' or 'worse' according to their distance from the technological frontier. In other words, inter-firm differences in performance are interpreted as an implication of different accumulation of technological capabilities (Dosi, 1985, 1988). In the 'late-industrialising' literature there are some classical studies that have sought to investigate the association between operational performance improvement firms' technological capability (e.g. Hollander, 1965; Katz et al., 1978; Dahlman and Fonseca, 1978; Bell et al., 1982; Mlawa, 1983). In Piccinini (1993), for instance, the association between technological capability and energy performance in two steel companies in Brazil was investigated. The study found that the company that dynamically accumulated technological capability by making use of interactive knowledge flows had a better energy performance than the company that did not. However, the companies' paths of technological capability-accumulation were not constructed.

Moving forward in relation to this study and focusing on these industries in one country, this paper asks: Have firms in process-intensive and natural resources-relates industries in Brazil like pulp and paper built up capability that had permitted them to catch up with but also overtake early innovators? If so, what have been the outcomes of innovative capability building for performance indicators in latecomer process-intensive industries like pulp and paper in Brazil over time?

3. Analytical Framework

As argued within the RBV (and extended versions), the evolutionary and assimilation theories Nelson and Winter, 1982; Dosi, 1988; Pavitt, 1998; Nelson & Pack, 1999) and dynamics capabilities framework, firms' capabilities as their essential resources to achieve sustained superior innovative and techno-economic performance the global market place. As a result, firms can be generally ranked as "better" or "worse" according to their distance from the technological frontier' (Dosi, 1988:1155-6) and 'firms in a sector have some commonalities and, at the same time, are heterogeneous (Malerba, 2005: 385). Such differences across firms and industrial sectors in terms of innovative efforts are expected to occur as a result of differing demands, sources of innovation and appropriability mechanisms (Pavitt, 1984; Dosi, 1988; Malerba, 2005).

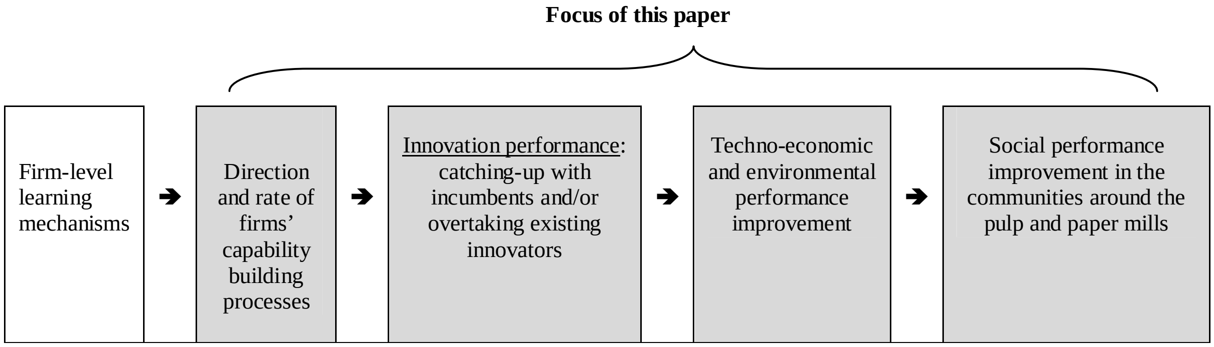
These resources enable firms to carry out *production* and different levels of *innovation* activities and are accumulated and embodied in individuals (skills, knowledge and experience) and organisational systems (Bell and Pavitt, 1993; 1995). These organisational systems (or capabilities) are formed by process and routines that permit the firm create, adapt and resources to achieve production and/or innovation goals.

Mathews (2002) draws on the resource-based theory of the firm, but give it a 'twist' "which makes it applicable to the case of a firm just starting out on its resource-acquisition trajectory". This is' is later elaborated in Mathews' (2006) through the RARE framework that "posed in a general setting of disequilibrium, enables us to capture each of the three perspectives utilized now – the ABV, the RBV, and the DCP..." (p. 165). As pointed out in Matthews (2006), "it can be utilized to make sense of the growth of entrepreneurial new ventures or of latecomer firms seeking to pursue fast follower strategies, as well as of traditionally studied issues such as resource exchanges in mergers and acquisitions" (p. 165).

In line with Mathews (2006), but considering the frameworks in Dutrénit (2000), Forbes and Wield (2000), Bessant et al. 2002, Hobday et al. (2004), Dantas (2006) we are interested in the processes by which latecomer firms catch-up but also move further to overtake existing incumbents to achieve a leading international positions the global market. These latter four studies identified some features of this transition from latecomers in leaders. We add a successful transition involves a firm-level capability building characterised by two interconnected dimensions: (i) an entrepreneurial management that is able to sense and seize technological opportunities to explored (Teece, 2007a,b) and (ii) this in turn, impinge on the firm an entrepreneurial capacity that, once provoked and nurtured, involve elements of co-ordination, combination, and frequent re-configuration of the firm's knowledge assets in order to excel in innovation performance (Pavitt, 1998; Bessant et al., 2004; Teece, 2007a,b).

However, this process does not occur in a vacuum and, as argued in studies concerned with capability building in latecomer countries, it is influenced by industrial policy regimes and government broader policies (Bell et al. 1982; Bell, 1984; Bell and Pavitt, 1993) and institutional frameworks (Nelson, 2007; Fagerberg and Verspagen, 2007). Thus, is in the context of such a framework that this article examines the process of the technological capability accumulation in a sample of pulp and paper mills in Brazil across broad industrial policy regimes, as illustrated in the framework in Figure 1 below.

Figure 1. The paper's analytical framework and focus



One of the main limitations of the present paper is that it does not cover key factors influencing firms' capability development such external and internal learning mechanisms (Bell, 1984; Malerba, 1992; Kim, 1997; Dutrénit, 2000; Figueiredo, 2001). These are however outside the scope of this paper.

In order to examine the capability building related to catching-up and overtaking processes, we used the Lall/Bell-Pavitt framework (Appendix Tables A and B) that distinguishes between levels of *production* and *innovative* capability across different technical 'functions' (types).

4. Pulp and paper technology and industries

Pulp and paper industries are highly intensive in capital, processes, and scale (Pavitt, 1984). The process of making paper involves the conversion of wood chips into pulp which, in turn, is processed to create paper, cardboard and a range of other products. It is complex mix of chemical and physical reactions, which normally place in continuous modes. Pulp is the main raw material used in the production of virgin-fibre paper and paperboard.[3] Fibres are long structures, formed by a microscopic size plant cell, not wide but long, hollow and with walls that vary in width.

Pulp can be categorized according to what type of wood species is used and the length of the wood fibres. Softwood pulp is based on long-fibre wood species (e.g. pine). Hardwood pulp is based on short-fibre wood species with broad leaves (e.g. eucalyptus). Pulp can be classified by the production process used to separate the three main components of the wood: cellulose, water and lignin[4]: chemical (wood cooked with chemicals) and mechanical (wood ground with physical force), or a combination. Pulp and paper mills can be 'integrated' and 'non-integrated'.[5]

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[3] Pulp consists primarily of cellulose. Chemically, cellulose is a long-chained carbohydrate consisting of repeating chains of a single simple sugar, glucose. Pulp is a generic term for a wide range of technically distinct products resulting from complex manufacturing processes that involve the chemical and/or mechanical treatment of various types of plant material. Wood currently provides the basis for approximately 90% of global pulp production; the remaining 10% begins as straw bamboo, bagasse, kenaf, flax, hemp, cotton, etc.

[4] Lignin acts as the cementing agent in wood, binding the cellulose fibres together.

[5] An 'integrated pulp' produces pulp exclusively for the on-site paper mill, and/or a paper mill which sources all its fibre from the on-site pulp mill). 'Non-integrated' mill is a pulp mill without an on-site paper mill, or is a paper mill without an on-site pulp mill.

Historically, the world's main producers and innovators in the market pulp industry have been the so-called Norscan countries (Canada, US and three Nordic countries: Sweden, Finland and Norway). However, during the late 1970s Brazil and Chile began to emerge as major market pulp producers, while Indonesia intensified its supplies from the early 1990s. As a result, the participation of Norscan countries in the world market pulp capacity has been declining over the past two decades: from 70 percent (1990) to 50 percent in 2005 and estimate of 44 percent by 2020. The share of developing countries in the world pulp and paper production markets evolved from 7 percent in the early 1970s to 23 and 26 percent, respectively, in 2005. Similarly, their participation in the world export market of pulp and paper grew from 3 and 1 percent, respectively, in the 1970s to 21 and 12 percent, respectively, in 2005 (FAO, 2006).

During the 1950s and 1960s, the world average paper and paperboard demand growth was around 5-6 percent, slowed down to 3 percent annually from the 1970s to the 1990s and to 2.4 percent annually in 2000-2004, reaching a world record of 359 million tonnes in 2004. From 2005 to 2007, there has been an average annual growth of 2.5 percent. By 2010 the world consumption is expected to reach 400 million tonnes of paper products with an estimated consumption of 450 million tons by 2015. Paper consumption in developing countries has grown more than 7 percent annually between 1980 and 1994 (China, Eastern Europe, Russia, Asia and Latin America), while there has been less consumption in Canada and US.[6] Indeed, since the early 1960s, world paper use has grown almost 6-fold and per capita consumption of paper has doubled.

Pulp production in Brazil evolved from 0.8 million tonnes in 1970 to 11.9 in 2007, or by 7.6 per cent annually on average, while paper production evolved from 1.1 tonnes (1970) to 9.0 million tonnes in 2007, or by 5.8 per cent annually on average. In 2007 Brazil is the world's sixth pulp producer (all types), first as a producer of hardwood (short fibre) pulp, and eleventh producer of paper. Specifically, Brazil's participation world hardwood pulp production grew from 39 per cent in 1990 to 50 per cent in 2007, Chile's evolved from 5.2 per cent in 1995 to 10 percent in 2007, while China's decreased from 4 percent in 2005 to 3.5 in 2007. The pulp and paper industries in Brazil consist of 220 firms spread in 17 states, but 85 per cent of production is concentrated in 12 large firms located mainly in the Southeast and South regions.

5. Research Methods

5.1 Firms selection, sources and types of evidence and data-gathering techniques

To address the questions outlined in Section 2, this paper draws on evidence from nine pulp and 11 paper mills in Brazil. The sample combines mills of different ages, sizes, types of ownership and corporate structure and market orientation (see Table 1), located in five different states in South-eastern Brazil.

[6] This seems to be primarily because of e-communications and the new habits of younger generation that tend not making use of newspapers. Nevertheless, during the early 2000s personal computers alone accounted for 115 billion sheets per year worldwide.

Table 1. Some key characteristics of the sampled pulp and paper mills

Sampled pulp and paper mills	Year of start-up	Age in 2006	Type of mill activity	Main product	Size of mill [e]	Ownership in 2006 (local/foreign)	Corporate structure in which they operate	Market orientation
Kappa	1941	65	Pulp and paper	Pulp Paper	Medium Medium	Brazilian	Conglomerate	Domestic Export
Delta	1945	61	Pulp and paper	Paper	Medium	Brazilian	Conglomerate	Export
Zeta-A	1954 (1990)[a]	52	Pulp and paper	Paper	Small	Brazilian	Specialised	Domestic
Sigma-A	1956 (1985)[b]	50	Pulp and paper	Pulp Paper	Large Small	Brazilian	Conglomerate	Export Export
Gamma	1960 (1990) [c]	46	Pulp and paper	Paper	Medium	Foreign	Specialised	Domestic
Lambda	1966	40	Paper	Paper	Small	Brazilian	Specialised	Domestic
Theta	1974	32	Pulp and Paper	Paper	Small	Foreign	Specialised	Domestic
Beta	1975	31	Pulp	Pulp	Large	Foreign	Specialised	Export
Alpha	1978	28	Pulp	Pulp	Large	Brazilian	Specialised	Export
Iota	1978	28	Paper	Paper	Small	Brazilian	Specialised	Domestic
Epsilon	1980 (1990)[d]	26	Paper	Paper	Small	Brazilian	Conglomerate	Domestic
Zeta-B	1985	21	Paper	Paper	Small	Brazilian	Specialised	Domestic
Sigma-B	1988	18	Pulp and paper	Paper	Medium	Brazilian	Conglomerate	Export

Notes: (a-d) Years between brackets are those in which these mills began to operate under new ownership. The sampled mills are examined here from these years of new ownership. Nevertheless, we have considered their existing technological capabilities during the year of ownership change. (e) Size was assessed on the basis of installed capacity/scale of production: <u>Small</u> (up to 300,000 tpy); <u>Medium</u> (301,000 to 999,000 tpy); <u>Large</u> (above 1,000,000 tpy)

Key criterion for selecting these firms was based on purposeful sampling in order to choose information-rich cases from which one can learn a great deal about issues of central importance to the research purpose (Patton, 1990). The companies and mills were selected on the basis of consultation of databases of the Brazilian Association of the Pulp and Paper Industry (Bracelpa) the Brazilian Technical Association of Pulp and Paper Industries (ABPTCP). The sampling process went through four phases as represented in Table 2.

Table 2. Sampling process for the researched mills

Sectors	Phase 1		→	Phase 2		→	Phase 3		→	Phase 4
	Number of active companies in Brazil	Share in Brazil's output		Number of most representative companies in Brazil	Share in Brazil's output		Selected companies	Share in Brazil's output		Selected mills
Pulp	63	100%	→	19	97%	→	8	81%	→	9
Paper	180	100%	→	29	77%	→	9	53%	→	11

The evidence-gathering process involved the access to different sources and diverse data-gathering strategies over three phases of extensive fieldwork (see Tables 3 and 4). The implementation of such strategy produced a rich amount of first-hand qualitative and quantitative empirical evidence. Rather than reducing all the qualitative data to quantitative observations, the strategy here sought to combine both types of evidence in order to enrich the empirical analysis. Used thus, the qualitative evidence, presented here partly in the form of narratives, helps both strengthen the arguments and establish causal relationships (Dougherty, 2002), as well as interpret the quantitative evidence (Figueiredo, 2001).

Table 3. Data gathering techniques and sources of empirical evidence in the researched firms (exploratory, pilot work studies and main fieldwork)

Techniques	Sources of evidence
(1) Over 150 open-ended interviews with five groups of interviewees	Group 1. Presidents, vice-presidents, industrial directors, planning, development, commercial/market finance, and investments directors.
	Group 2. General plant managers, managers of production units (e.g. pulping, utilities), managers of production support units (e.g. quality control, maintenance, R&D departments, laboratories).
	Group 3. Engineers, technicians, foremen and operators of different production units. Managers, engineers, researchers and technicians from production support units and control rooms.
	Group 4. Corporate managers (planning, human resources, finance, logistics, investments, marketing)
	Group 5. Former company's members and officers in the pulp and paper industries related organisations in Brazil.
(2) Direct-site observations	These involved the observation of companies' people at work (e.g. engineers, operators), meetings, and their presentations in the firms' events.
(3) Casual meetings (informal 'snow-balling' interviews derived and relatively unplanned meetings)	Corporate and plant managers, production units managers, engineers and technicians, engineers and technicians in production support units.
(4) Companies' publications and archives	This material was gathered in the form of annual reports, internal bulletins and newspapers, organisational charts, institutional CD-ROMs and videos, commemorative and historic institutional publications, technical papers published by the firms' individuals, reports on technical visits, files and presentations about technological projects, and copies of staff's presentations, internal and external.
(5) Forms filled in by targeted informants	After the completion of the main fieldwork, over 250 forms were sent out to targeted respondents inside the sampled companies. In these forms, different informants inside the researched firms had to provide information (qualitative and quantitative) relative to the main issues involved in the

	research

Table 4. Evidence gathering strategies during the fieldwork

Phases of fieldwork	Companies										PPI related organisations in Brazil		Overall number of data gathering activities during the whole study
	Formal interviews (individual, collective and snow-balling)		Informal Interviews and casual meetings		Direct-site observations [b]		Consultations to archives and publications [c]		Enquiry forms responded by targeted respondents	Total data-gathering activities within companies	Formal interviews	Consultation into archives and publications	
	C.O. [a]	Mills	C.O.	Mills	C.O.	Mills	C.O.	Mills					
Exploratory June – September 2005	4	None	1	2	None	None	2	None	None	9	3	3	15
Pilot work January – February 2006	2	48	4	13	2	5	4	6	None	84	4	6	94
Main fieldwork May – December 2006	7	94	None	24	4	8	5	10	259	411	4	6	421
Totals	**13**	**142**	**5**	**39**	**6**	**13**	**11**	**16**	**259**	**504**	**11**	**15**	**530**

Notes: (a) C.O = Corporate office; (b) The counting of each observation was based on each plant or office guided whereby the research observed the workplace organisation, plant aspects, attended presentations, listened to description of functioning/evolution of specific production flow, equipment, software, database, organisational arrangement, managerial technique, or archive; (c) This was counted on the basis of each access the research team had on those sources

Main fieldwork for this research was carried out from September 2005 to December 2006. Supplementary data-gathering, clarifications, validations and double/triple checking and follow-ups were carried out from January to July 2007 on the basis of short visits, several phone calls and emails. After the completion of the main fieldwork, a total of 259 forms were sent to targeted informants inside the researched firms. By filling in these forms, such informants (or groups of them) provided detailed qualitative and quantitative evidence about specific issues covered in this study. The analysis process involved the building of descriptive and analytical tables to examine the issues covered in the study underpinning this paper in different points in time. Such procedure allowed us to have a close view on the patterns of each issue examined in this study and how such patterns and their inter-relationships changed over time (Miles & Huberman, 1984; Leonard-Barton, 1995b; Figueiredo, 2001). Such method paid off by generating a wealth of detailed analyses, but it proved a daunting task with several trial-and-errors that required extreme patience and persistence of the research team.

6. Empirical Analysis and Discussions

We begin by showing evidence relative to the researched mills that, by the end of fieldwork, had attained *production* and *innovative* capabilities for specific technological functions (Section 6.1). Section 6.2 examines evidence of the nature and direction of accumulation of such capabilities. We pay less attention to the accumulation of *production* capabilities, since we are interested in the nature of the process by which these firms have moved through different levels of innovation capabilities and the extent to which they have caught up with and overtaken early innovators, especially in Norscan countries. Section 6.3 contains evidence and analyses relative to speed (rate) of the accumulation of capabilities in the researched mills.

6.1 Capability building paths in the researched pulp and paper mills in Brazil

6.1.1 Types and levels of capability for specific technological functions in the mills

The evidence in Table 5 shows that, in terms of capability building for specific technological functions, all pulp and paper mills have caught up with international production levels of capabilities. Like Indonesia's (see van Dijk and Bell, 2007), their technological capabilities for production-related activities embody advanced technical and organisational features that match world leading pulp and paper companies at the international *production* frontier. In parallel, and most importantly, the great majority of pulp and paper mills have moved into the building of innovative levels of capability, across all four technical functions. Some have approached or closed the gap with internationally innovative technological levels, while a few have moved beyond catch-up to overtake early innovators in Norscan countries thus attaining leading positions at the global innovation frontier. These mills belong to firms that respond for the large majority of output, productivity, investments in the Brazilian pulp and paper industries. All these firms are of Brazilian capital ownership.

Table 5. Number of sampled pulp and paper mills that have reached particular levels capability for specific technical functions (by the end of fieldwork – December 2006)

Levels of technological capabilities	**Project Management**		**Process and Production Organization**		**Process Equipment-related activities**		**Product-related Activities**	
	Pulp	**Paper**	**Pulp**	**Paper**	**Pulp**	**Paper**	**Pulp**	**Paper**
Capabilities to carry out innovations at the technological innovation frontier level								
(6) Innovation frontier	**5** **(56%)** Delta Alpha Sigma-A Sigma-B Kappa	**4** **(36.4%)** Delta Alpha Sigma-A Sigma-B Kappa	**5** **(56%)** Alpha Delta Gamma Sigma-A Sigma-B	**3** **(27.3%)** Delta Gamma Kappa	Not reached	Not reached	**2** **(22%)** Alpha Sigma-A	**1** **(9.1%)** Delta
Capabilities to carry out innovative activities towards near the technological innovation frontier								
(5) Advanced innovation	**6** **(67%)** Alpha Delta Sigma-A Sigma-B Kappa Theta	**5** **(45.5%)** Delta Sigma-A Sigma-B Kappa Theta	**5** **(56%)** Alpha Delta Gamma Sigma-A Sigma-B	**8** **(72.7%)** Delta Epsilon Gamma Sigma-A Sigma-B Kappa Zeta-B Theta	**7** **(78%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa	**5** **(45.5%)** Delta Sigma-A Sigma-B Kappa Zeta-B	**4** **(44%)** Alpha Delta Sigma-A Sigma-B	**8** **(72.7%)** Delta Epsilon Gamma Sigma-A Sigma-B Kappa Lambda Zeta-B
(4) Intermediate innovation	**8** **(89%)** Alpha Beta Delta Sigma-A Sigma-B Kappa Zeta-A Theta	**9** **(81.8%)** Delta Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**7** **(78%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**5** **(56%)** Alpha Beta Delta Sigma-A Sigma-B	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta
(3) Basic innovation	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**8** **(89%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**8** **(89%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta
Capabilities to use existing technologies and production system								
(2)	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta
(1) Basic operations	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta	**9** **(100%)** Alpha Beta Delta Gamma Sigma-A Sigma-B Kappa Zeta-A Theta	**11** **(100%)** Delta Epsilon Gamma Iota Sigma-A Sigma-B Kappa Lambda Zeta-A Zeta-B Theta

Note: For mills Zeta-A, Sigma-A, Gamma, and Epsilon (see footnote in Table 1), their capabilities accumulated under previous ownership were considered as 'entry' capabilities to the period covered by our study. *Source:* Derived from the empirical study

More specifically, all pulp and paper mills have accumulated production-based (Levels 1 and 2) and basic innovation capability (Level 3) for the great majority of technical functions. Variations across the two sectors, across mills and technical functions appear from Level 4 capability. The great majority of the pulp and paper mills have moved from Level 4 into advanced Level 5 thus catching up with international capability levels, particularly for project management, process and production organisation and process equipment.

With regard to product-centred capability, a higher proportion of paper mills compared to pulp mills have caught up with international levels. Among the mills that have caught up, the majority has crossed a technological threshold to reach the innovation frontier level, especially for project engineering management and process and production organisation, while two mills have done that for product-centred activities. Compared to pulp, a smaller proportion of mills have reached the innovation frontier level in terms of capability for these two technical functions, while one mill did so for product-centred activities.

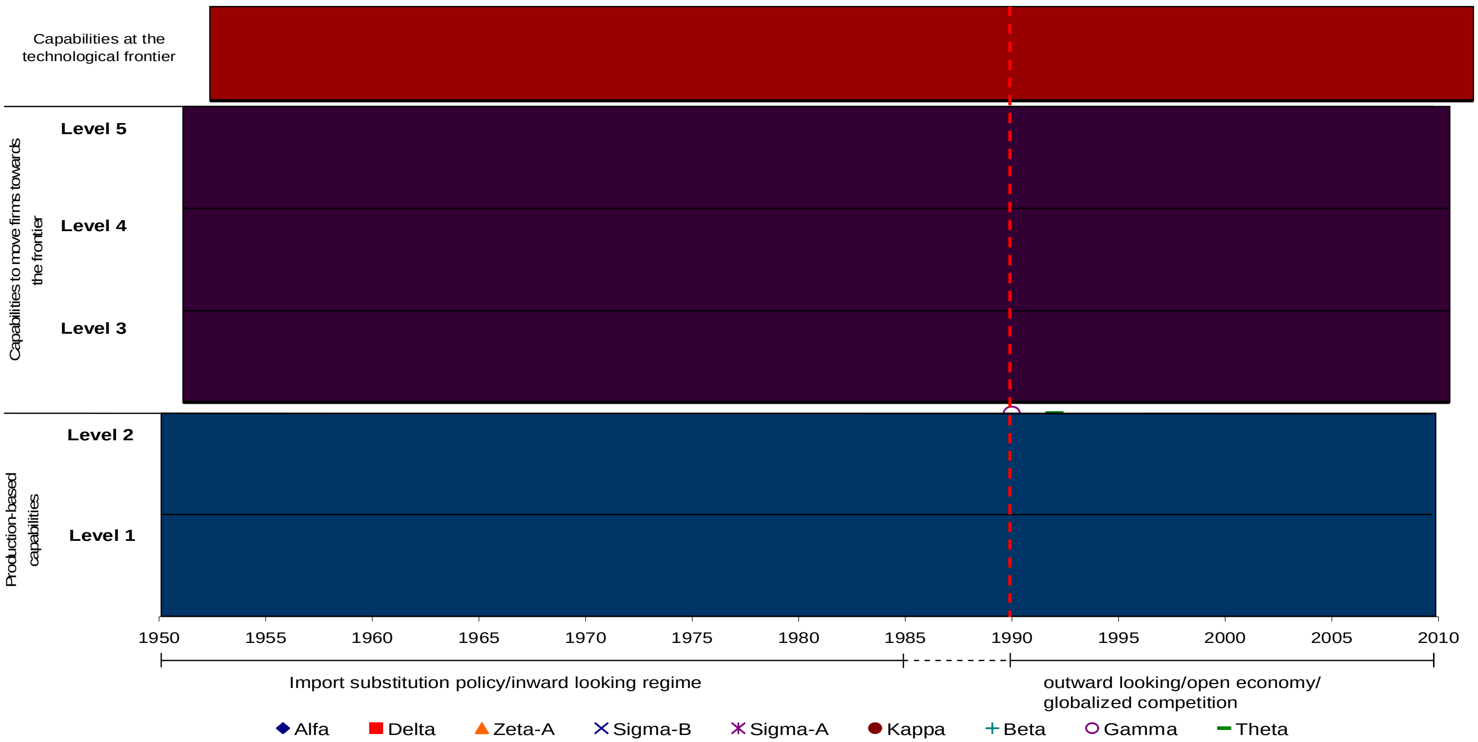
6.1.2 Direction of Brazil's pulp and paper industries across different policy frameworks

While Section 6.2.1 provides a perspective of the direction of the mills' capability accumulation process based on quantitative capability indexes, Section 6.2.2 examines the process of growth and capability building in the pulp and paper industries in Brazil, across different policy frameworks, especially the researched mills, based on qualitative evidence.

6.1.2.1 Evolution of capability accumulation indexes in the pulp and paper mills

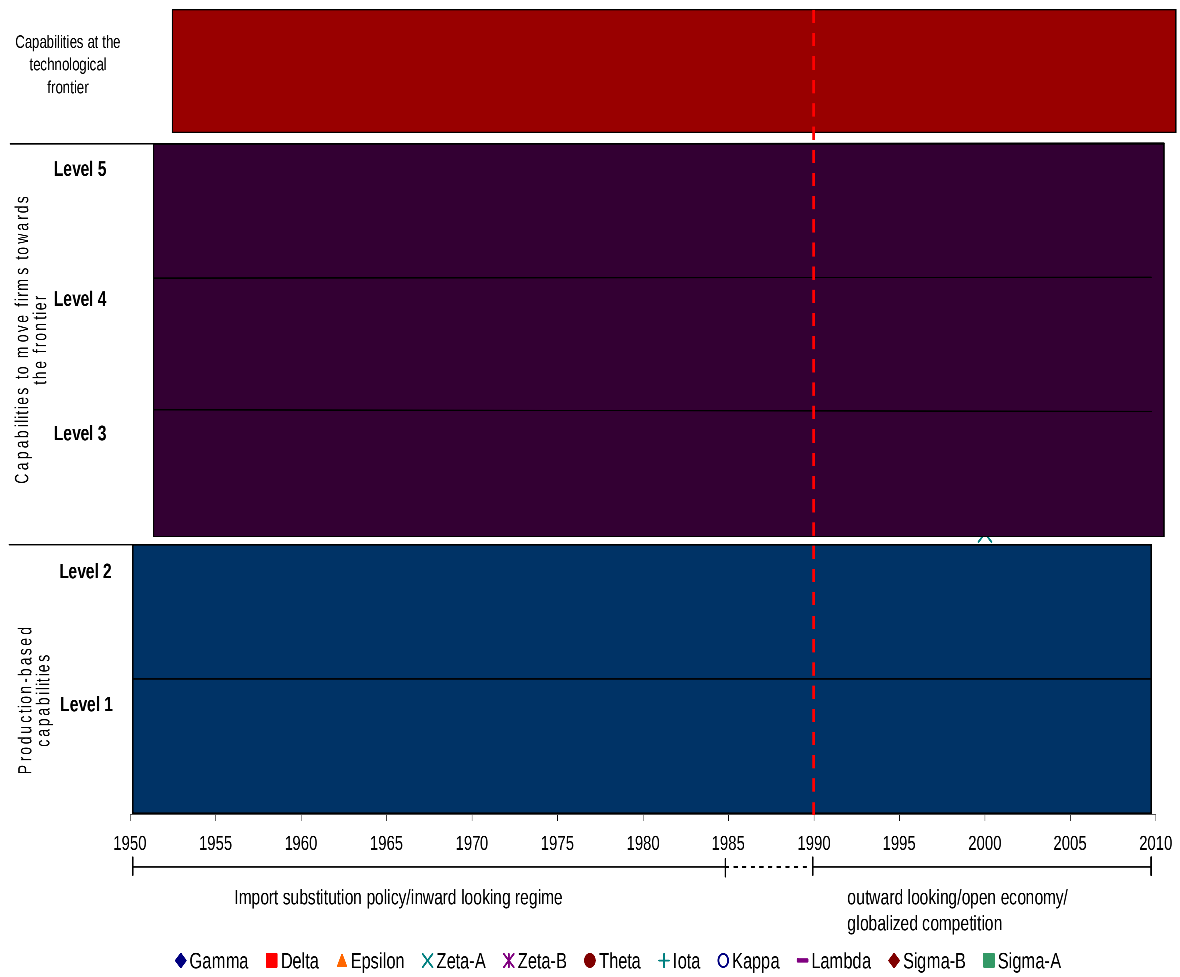
In order to obtain a quantitative, aggregated and, especially, a *dynamic* perspective on capability accumulation in the researched pulp and paper mills we have created the technological capabilities indexes (TCI). The construction of such indexes here was built on Dutrénit et al. (2002). Specifically, such index refers to a quantitative measure of the levels of capabilities for each of the technical functions examined here. The evolution of these capability indexes, aggregated by mills, is sown in Figures 2 (pulp) and 3 (paper).

Figure 2. Technological capability accumulation paths of the researched pulp mills (aggregated): from catching up to overtaking



Source: Derived from the empirical study

Figure 3. Technological capability accumulation paths of the researched paper mills (aggregated): from catching up to overtaking



Source: Derived from the empirical study

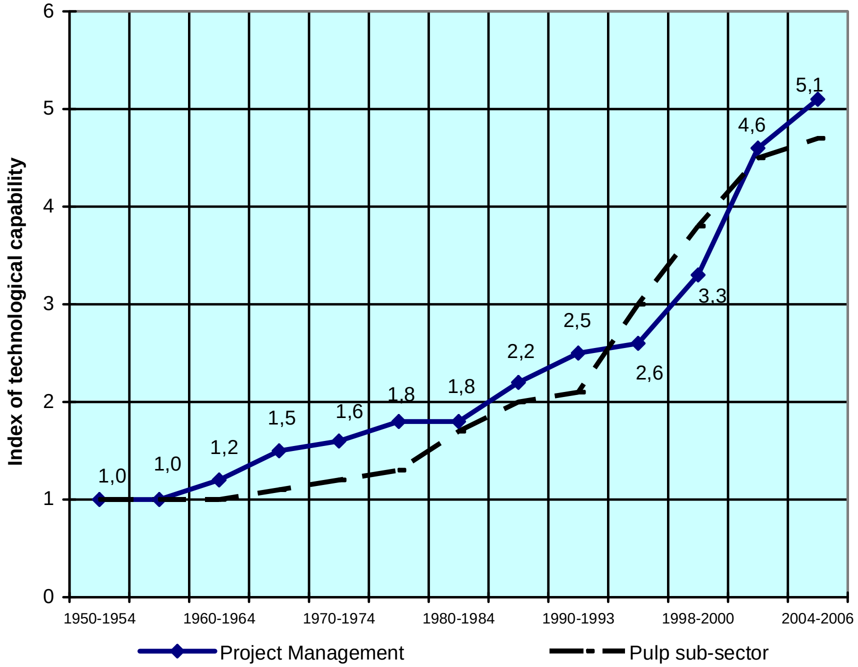
During the ISI period the capability levels of both pulp and paper mills were predominantly convergent and homogenous around Levels 1 and 3. During the period of structural economic and industrial policy reforms (early 1990s), we observe a certain disruption in that pattern marked by relatively high heterogeneity and divergence among mills in terms of capability levels. From the early 2000s, there was a restored homogeneity and convergence of the mills' capability levels around innovative territory, especially around Levels 4 and 6, with some at the innovation frontier.

Figures 4 to 7 provides evidence capability accumulation indexes for each of the four specific technical functions. In each figure we contrast the capability accumulation path for each function against the average aggregated index (all mills).

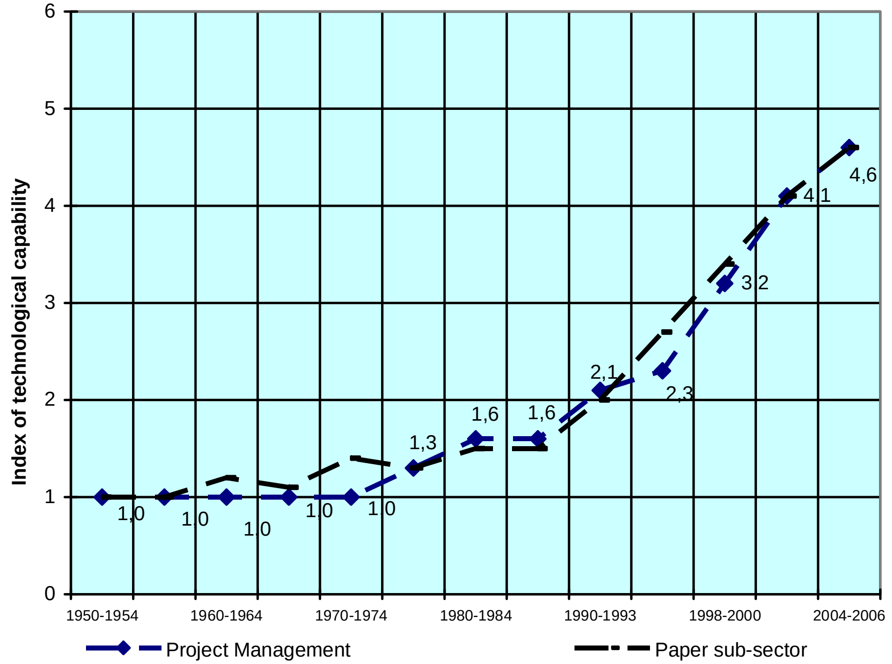
In general, we have observed that the trajectory of capability accumulation for different technical functions in the pulp sample began to move into innovative territory much earlier (early 1980s) as compared to the paper mills. For these, it was not until the early 1990s that they began to engage in innovative activities. From that period, we observe that the capability paths evolved relatively together and a greater convergence among these four functions around the industry level is observed from the early 1990s. Differently, within the paper sample from the early 1950s up to the mid-1980s the capability accumulation paths were confined to the production-based territory. During the 1985-2001 period there was a relative divergence among these trajectories. It was not until the early 2000s that a convergence across these paths towards high innovative capability levels established.

Figure 4. Capability accumulation path for project management activities in the pulp and paper mills (aggregated at the level of specific technical functions *vs.* sector level) 1950-2006

Pulp

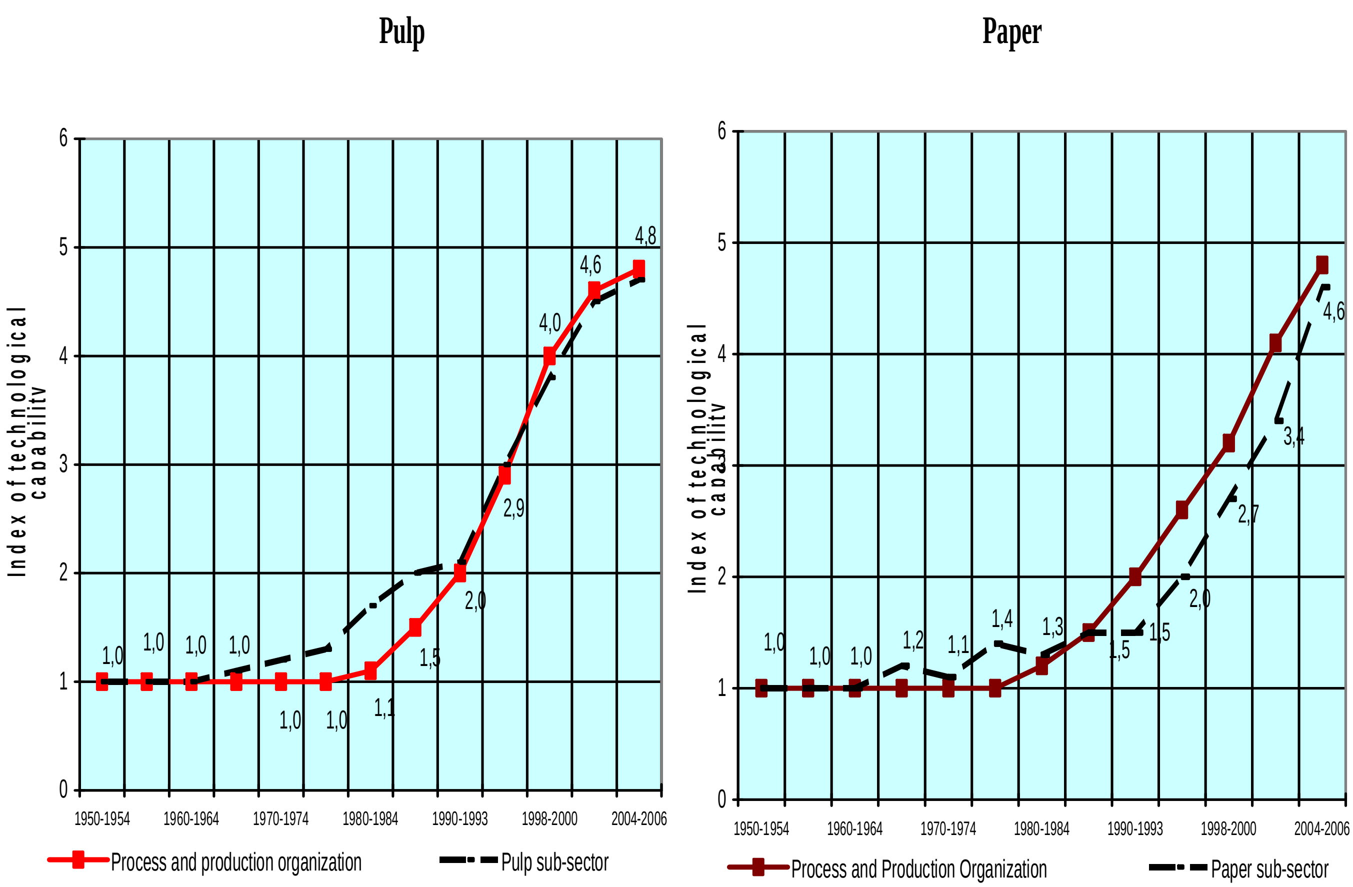


Paper



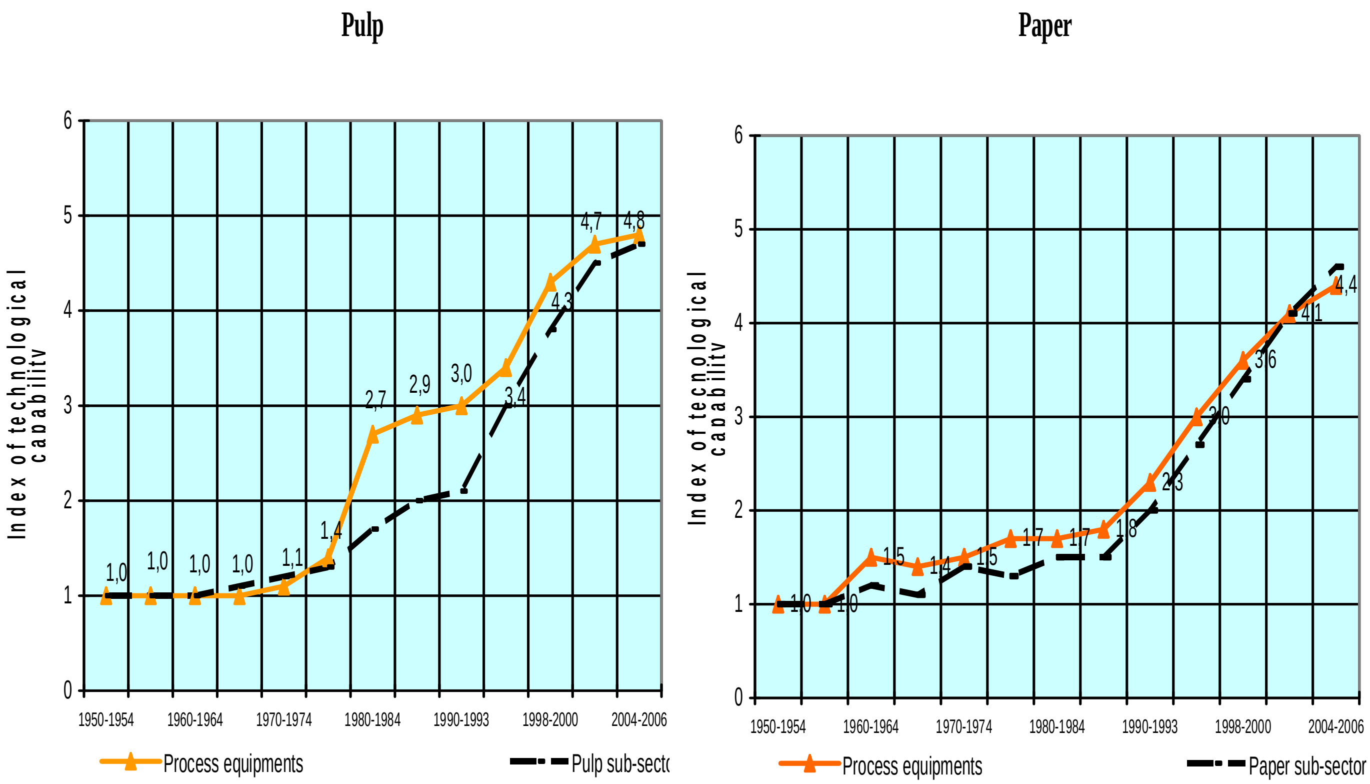
Source: Derived from the empirical study

Figure 5. Capability accumulation path for process and production organisation activities in the pulp and paper mills (aggregated at the level of a specific technical function *vs.* sector level) 1950-2006



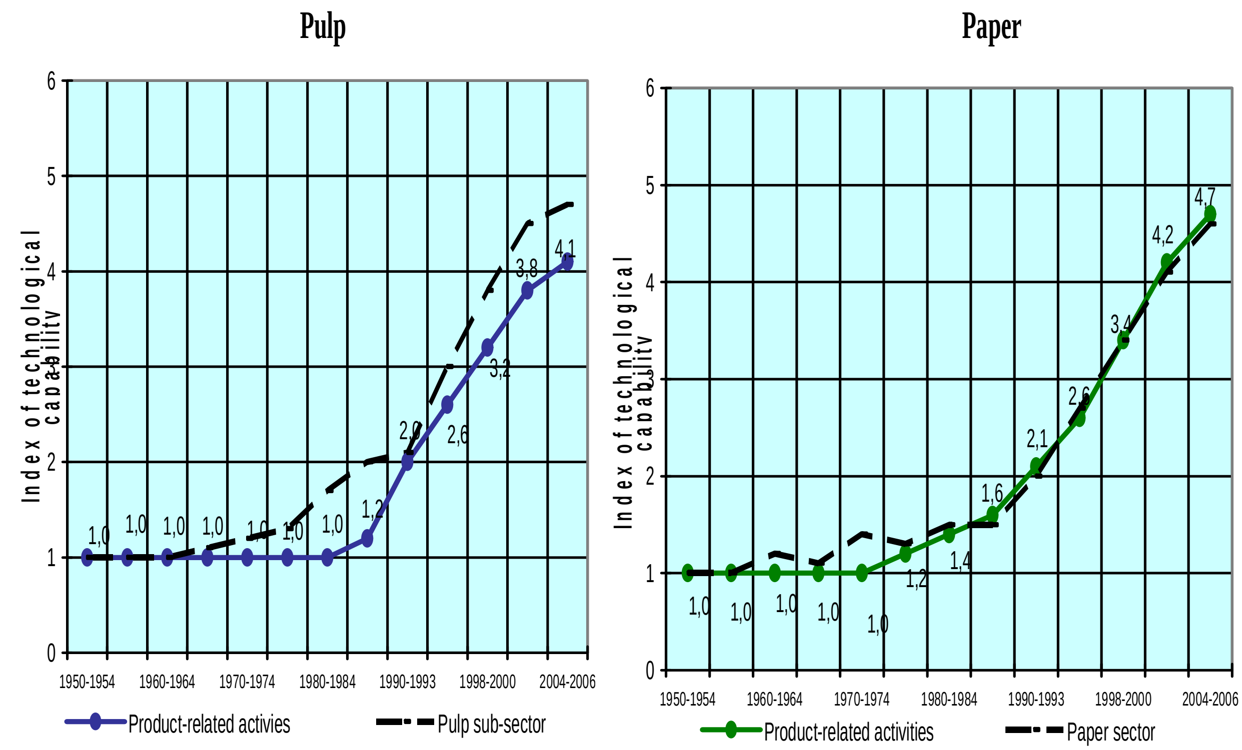
Source: Derived from the empirical study

Figure 6. Capability accumulation paths for process equipment related activities in the pulp and paper mills (aggregated at the level of a specific technical function vs. sector level) 1950-2006



Source: Derived from the empirical study

Figure 7. Capability accumulation paths for product-related activities in the sampled pulp and paper mills (aggregated at the level of a specific technical function *vs.* overall level) 1950-2006



Source: Derived from the empirical study.

6.2 Some Outcomes of Capability Building in the Researched Mills (and around them)

In this section we will address some of the implications of capability building in the researched pulp and paper mills for improvement in three types of 'performance' indicators: (i) process-related; (ii) environment-related and (iii) social-related.

6.2.1 Evolution of process-related performance indicators in the pulp and paper mills

Drawing on Figueiredo (2001, 2002), but seeking to move a step forward, Figueiredo et al. (2008) sought to examine the extent to which the improvements in a set of process indicators could be associated with the innovative capability processes in a set of seven forest firms, nine pulp mills and eleven paper mills. Within the pulp mills the following process indicators we examined during the 1990-1995 (scattered) and more consistently during the 2000-2006 period: specific steam consumption, specific electrical energy consumption, specific water consumption, fibre losses. During period examined these indicators reduced by 3.5 percent annually on average. During this period the capability index relative to process activities increased by 2.08 percent annually on average and the overall capability index of firms increased by 1.2 percent annually on average. On the basis of qualitative evidence the study found clear associations between improvements in these indicators and innovative capability building efforts. These efforts were driven by the economic needs to improve performance.

For the paper mills the study considered the following indicators: specific steam consumption, specific electrical energy consumption, specific water consumption. Each of these indicators was considered in relation to process for different types of papers: printing and writing, packaging, wrapping and boxboard, and tissue.

The study found substantial improvement on these indicators over the examined period. Drawing on a combination between qualitative and quantitative evidence the study found a positive association (not causality) between efforts on innovative capability building and improvement on process indicators within the pulp and paper firms.

6.2.2 Evolution of some environment-related performance improvement

These indicators were examined within the researched pulp and paper mills. The indicators involved 12 indicators related to environmental performance (involving liquid, solid, and air emissions), as shown in Tables 6 to 9 and Figure 8 below.

Table 6. Evolution of some process performance indicators in the researched pulp mills (2000-2006)

Process performance indicators in the pulp mills[(a)]		**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**Average annual rate of reduction/increase (%) (2000-2006)**
1. Specific steam consumption	Steam ton/ pulp weight (ton)	4.92	5.41	4.88	4.94	4.54	4.41	3.63	–4.93
2. Specific electrical energy consumption	KWh/ pulp weight (ton)	737.03	730.51	640.89	646.40	674.22	639.67	571.02	–4.16
3. Specific water consumption	m^3/ pulp weight (ton)	41.30	45.60	42.74	39.67	40.96	40.16	36.78	–1.91
4. Fiber losses	ton/day	13.16	16.78	15.56	11.19	8.89	9.51	10.92	–3.06
Aggregate indexes of technological capability in the researched pulp mills		4.04	4.43	4.43	4.60	4.71	4.71	4.71	+2.58
Project management activities		3.67	4.44	4.44	5.00	5.11	5.11	5.11	+5.69
Process and production organization activities		4.22	4.56	4.56	4.67	4.78	4.78	4.78	+2.08
Product-related activities		3.33	3.67	3.67	4.06	4.06	4.06	4.06	+3.32
Process equipment-related activities		4.44	4.67	4.67	4.67	4.78	4.78	4.78	+1.21

Source: Derived from the empirical study. *Notes*: (a) The lower the better

Table 7. Evolution of some process performance indicators in the researched paper mills (2000-2006) [(a)]

Process performance indicators	Units	2000	2001	2002	2003	2004	2005	2006	Average annual rate of reduction/increase (2000-2006) (%)
Specific steam consumption [(b)]	Steam weight (ton)/ paper weight (ton)								
Printing and writing		3.12	2.99	2.82	2.73	2.62	2.56	2.49	–3.69
Packaging, wrapping & boxboard		1.90	2.00	3.50	3.27	2.04	1.97	1.90	0.00
Tissue		1.90	1.75	1.45	1.45	1.47	1.45	1.43	–4.62
Specific electrical energy consumption[(b)]	KWh/paper weight (ton)								
Printing and writing		627.50	614.33	591.97	576.17	572.00	554.50	547.00	–2.26
Packaging, wrapping & boxboard		457.51	465.22	655.00	725.87	486.36	432.84	391.95	–2.54
Tissue		412.07	473.54	439.26	458.18	447.12	398.27	229.5	-9.29
Specific water consumption [(b)]	m^3/ paper weight (ton)								
Printing and writing		28.00	26.20	24.60	20.80	19.20	18.00	17.10	–7.89
Packaging, wrapping & boxboard		31.65	32.50	32.66	33.51	23.28	19.35	20.12	–7.27
Tissue		34.80	33.15	31.85	30.60	28.95	25.80	23.30	–6.47
Aggregated indexes of technological capability in the paper mills		3.65	4.04	4.04	4.27	4.63	4.63	4.66	+4.19
Project management		3.55	3.91	3.91	4.55	4.64	4.64	4.64	+4.57
Process and production organization		3.64	4.09	4.09	4.18	4.82	4.82	4.86	+4.97
Product-related activities		3.64	4.18	4.18	4.27	4.73	4.73	4.73	+4.47
Process equipment-related activities		3.73	4.00	4.00	4.18	4.36	4.36	4.41	+2.84

Source: Derived from the empirical study.

Notes: (a) Aggregated by specific paper segments (printing and writing; packaging, wrapping and boxboard; tissue paper); (b) The lower, the better.

Table 8. Evolution of environment-related indicators of the researched pulp mills (2000-2006)

Types of Effluents	Environment-related indicators	Units	2000	2001	2002	2003	2004	2005	2006	Average annual rate of reduction/increase (2005-2006) (%)	Average annual rate of reduction/increase (2000-2006) (%)	Limits defined by CONAMA [c]
Liquid	Industrial effluents output	m^3/pulp weight(ton)	46.72	49.00	46.86	42.94	42.42	41.70	38.74	–7.09[a]	–3.07	50-100
	COD (Chemical oxygen demand)	Kg/ pulp weight(ton)	11.93	12.18	12.12	10.09	10.65	10.66	7.64	–28.34[a]	–7.16	10
	BOD (Biochemical oxygen demand)	Kg/ pulp weight(ton)	1.80	1.75	1.52	1.32	1.41	1.27	1.10	–14.00[a]	–7.88	2.5
	Total nitrogen	Kg/ pulp weight(ton)	0.23	0.16	0.14	0.10	0.11	0.10	n.a.	Not applicable	–1.50	n.r.
Solid	Lime mud/ dregs/grits	Kg/ pulp weight(ton)	33.91	62.40	58.31	43.52	44.33	86.41	68.05	–21.25[b]	12.31	n.r.
	Total ashes	Kg/ pulp weight(ton)	11.71	21.35	19.42	15.54	17.66	27.61	29.18	5.66[b]	16.44	n.r.
Air	SO_2 (chemical recovery boiler)	mg/Nm^3	8.82	17.12	10.31	24.00	15.78	14.99	7.15	–52.29[a]	–3.44	100
	NOX (chemical recovery boiler)	mg/Nm^3	NA	126.15	68.30	239.80	296.25	128.58	187.56	45.87[a]	8.25	470
	Particulate matter	mg/Nm^3	483.65	646.11	1054.0	601.10	720.03	524.53	n.a.	Not applicable	1.36	n.r.
	Average TRS (Total reduced sulphur)	ppm	1.64	0.92	2.31	0.82	9.70	3.80	2.13	–44.08[a]	4.47	n.r.
	Average SO_2	ppm	1.69	3.89	2.13	2.83	1.30	7.03	4.40	–37.39[a]	17.29	n.r.
	Average TRS (Lime kiln)	ppm	17.16	2.45	45.21	42.93	32.58	26.73	16.60	–37.88[a]	1.16	n.r.
Aggregated index of technological capability in the pulp mills			4.04	4.43	4.43	4.60	4.71	4.71	4.71	+2.58		
Project management			3.67	4.44	4.44	5.00	5.11	5.11	5.11	+5.69		
Process and production organization			4.22	4.56	4.56	4.67	4.78	4.78	4.78	+2.08		
Product-related activities			3.33	3.67	3.67	4.06	4.06	4.06	4.06	+3.32		
Process equipment-related activities			4.44	4.67	4.67	4.67	4.78	4.78	4.78	+1.21		

Source: Derived from the empirical study.

Notes: The Brazilian environmental standards below were taken as reference to the limits of indicators: (a) The lower, the better; (b) dependent on the production volume; (c) National Council of the Environment, Brazilian Ministry of Environment; n.a. = not available; n.r. = no reference.

Table 9. Evolution of environment-related indicators of the researched paper mills[a]

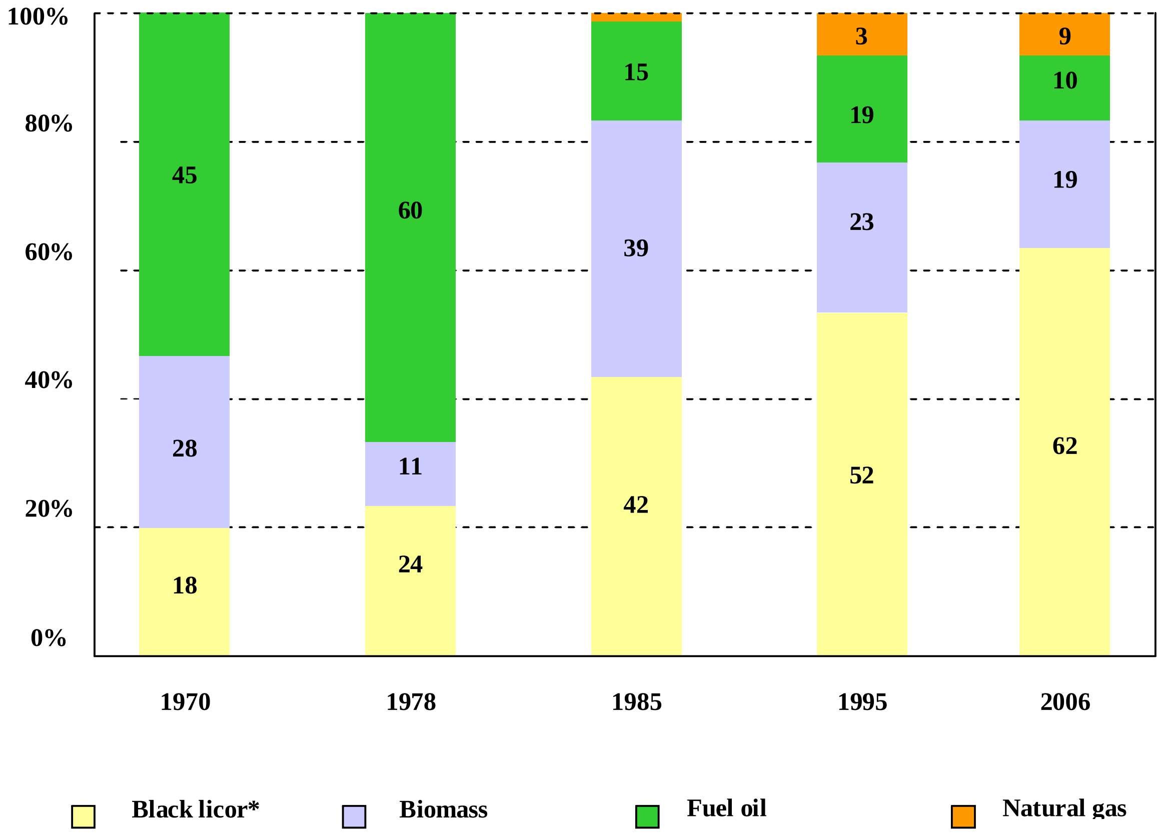
Environment Indicators	Units	2000	2001	2002	2003	2004	2005	2006	Average Annual Rate of Reduction/ Growth 2005-2006 (%)	Average Annual Rate of Reduction/ Growth 2000-2006 (%)	Limits defined by CONAMA
Industrial effluents output	m^3/ paper weight (ton)										
Packaging. wrapping & boxboard		28.45	28.42	25.18	37.46	38.81	38.21	39.78	4.11[b]	5.75	50-100
Tissue		90.00	80.00	80.00	46.19	43.47	34.19	31.77	−7.08[b]	−15.93	50-100
COD (Chemical oxygen demand)	Kg/ paper weight (ton)										
Packaging. wrapping & boxboard		7.23	6.31	12.76	10.06	10.96	4.99	7.12	42.69[b]	−0.26	10 [a]
Tissue		14.57	18.07	13.64	13.69	15.95	9.33	9.28	−0.54[b]	−7.25	10 [a]
BOD (Biochemical oxygen demand)	Kg/ paper weight (ton)										
Packaging. wrapping & boxboard		NA	NA	4.36	3.46	4.46	1.53	n.a.	Not applicable	–2.69	5
Tissue		3.89	5.06	4.32	5.42	5.62	2.40	2.07	–13.75[b]	–9.98	5
Aggregated index of technological capability in the paper mills		3.7	4.0	4.0	4.3	4.6	4.6	4.7	+4.19		
Project management		3.55	3.91	3.91	4.55	4.64	4.64	4.64	+4.57		
Process and production organization		3.64	4.09	4.09	4.18	4.82	4.82	4.86	+4.97		
Product-related activities		3.64	4.18	4.18	4.27	4.73	4.73	4.73	+4.47		
Process equipment-related activities		3.73	4.00	4.00	4.18	4.36	4.36	4.41	+2.84		

Source: Derived from the empirical study.

Notes: (a) Aggregated by specific paper segments (packaging, wrapping and boxboard; tissue paper); (b) The lower, the better.

(c) National Council of the Environment, Brazilian Ministry of Environment; n.a. = not available

Figure 8. Evolution of the Energy Matrix of Brazil's Pulp and Paper Industries (1970-2006)



Source: National Energy Balance
*Sub product (Biomass)

Notwithstanding the relevance of natural resource-based and process industries to the industrial and economic progress in developing countries, such sectors tend to be deemed, even within developing countries, as 'mature' producers of mere 'commodities' with very little (if any) involvement in innovative technological activity. Additionally, although such industrial sectors are normally addressed as 'key actors' (or 'villains') in studies and discourses of academics, consultants and development agencies relative to 'sustainability' , 'sustainable development' and 'corporate social responsibility', the reference to these industrial sectors and their firms are, with a few exception, dissociated from the issues of technological capability and innovation and their implications for the improvement of techno-economic and social performance related indicators. Put differently, such issues related to 'sustainability' (and their variations of terminologies) tend to be discussed and studied in their own right.

6.2.3 Evolution of some economic related indicators (at corporate level)

This section presents in a resumed way, the results about some economic indicators related to forest, pulp and paper industries during 1990 to 2005 period. These indicators are described in Appendix Table C. The analysis was based in financial statements counted in December, 31 of each related years, in the corporate level.

It could be observed in the Table 10, that the forest, pulp and paper industries shown a limited payment capability, but enough to perform one's duties until 1994. Before this period there was continuous changes with a marked improvement in performance from the 2003, which suggests a substantial improvement in the payment capability of firms. Similarly the debt ratio presented a stable tendency from 1999 after a period of continuous fluctuations. According this indicator, the policy to get resources from the forest, pulp and paper industries is offering less risks to capital of thirds, in so far the values of this indicator is lesser. Similar tendency was evidenced by the gross margin indicator, where the profitability of the industries has growing from 2002.

That is, show how much of net revenues to compose the economic performance of the firms, to each period. The difference of the gross margin and the net profit margin define the percentage of each US1 in sales that rested after the deduction of all expenses, less income tax and the not operational or extraordinary expenses. Therefore, the tendency of this indicator is change to each year, suggesting continuous changes in relation to sales and price variation. After 2002 is observed a substantial improvement in this indicator, that follow the tendency of the others indicators, suggesting a improvement in the financial frame of forest, pulp and paper industries.

6.2.4 Social-related performance indicators relative to the researched mills

Since its formation, the pulp industry and paper had an important paper as much for the states as for the creation and development of many Brazilian towns. Municipalities as Aracruz, in the state of Espirito Santo, and Telemaco Borba, in the state of the Parana, has its economy strongly dependant of the pulp and paper mills activities, although in last the ten years, comes appearing in each region other firms, mainly related the forest activity. Through the Tables 11 and 12 it is possible to observe that in 2006 the state of Sao Paulo, the municipality of Suzano was what it had the biggest number of people employed in the pulp and paper sector. The city that less employed in this sector was the municipality of Jacareí, located in the state of Sao Paulo.

Through the Table 11 it is presented the Human Development Index (HDI) of each municipality, state and in Brazil as a whole. It is necessary clarify that the data related to the city of Curitiba are bigger than others, for the fact to contain the capital of the state of the Paraná. The economy of the Bragança Paulista, Jacareí and Luis Antonio municipalities is mainly based in industrial activities, had their respective population employed in diverse sectors.

With respect to the level of labour productivity (the rate of industrial value added per employment in industry) in the industrial sector, it was only possible to get data in relation to the municipalities in the states of Sao Paulo and Parana. Through Table 13 it is observed that in the state of São Paulo the bigger growing in the labour productivity occurred in the municipality of Suzano (27%), followed for the municipality of Brangança Paulista (24,7%). Next the municipalities with significant an annual growth in the productivity was Nova Campina (22,8%) and Mogi Guaçu (20%). However, the municipality of Luis Antonio reached the most levels of productivity in comparison with other regions. In the state of the Parana, the biggest labor productivity was gotten in the municipality of Telemaco Borba, even so the Curitiba has presented a bigger annual growth of productivity (10%). Taking as reference the year of 2005, the biggest average income of the worker in the industry (Table 12) is reached in the municipality of Luis Antonio (US$ 1,178) followed by Jacarei (US$ 1,000). In the municipalities of Mogi Guaçu, Nova Campina and Suzano the average income in the industry was around US$ 800.

Table 10. Evolution of financial-economic indicators of sampled firms in pulp and paper in Brazil (1990-2005)

Indicator	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
MEAN																
Debt ratio	40.70	34.43	39.43	47.38	43.83	45.62	51.07	49.85	53.17	58.19	52.32	57.03	64.33	55.56	52.85	57.36
Current ratio	1.12	0.93	1.03	1.54	1.35	1.51	1.35	1.13	1.16	1.27	1.50	0.96	1.05	1.17	1.49	1.47
Quick ratio	0.71	0.51	0.61	1.27	1.09	1.23	1.12	0.91	0.98	1.09	1.25	0.77	0.92	0.94	1.20	1.21
Gross profit margin	34.55	29.08	21.03	18.40	30.21	35.71	24.52	26.04	26.55	38.52	41.40	35.34	40.56	40.94	39.88	34.50
Net profit margin	12.83	2.63	0.58	-13.72	16.53	16.26	-4.89	-4.06	-10.45	3.09	18.61	8.81	1.94	20.65	16.65	11.06
EBITDA margin	24.68	26.68	25.60	23.64	34.67	38.16	23.64	22.14	21.74	34.29	36.65	27.82	32.10	33.33	31.57	26.02
Return on assets	3.60	-0.90	-0.90	-1.40	2.70	0.28	-1.96	-1.12	-2.41	-2.09	5.23	0.92	-0.16	10.66	8.75	5.32
Operating leverage	3.87	4.47	1.57	1.05	2.63	1.79	3.55	2.68	3.96	1.55	1.47	1.73	1.64	1.61	1.75	1.76

Source: Derived from the empirical study

Table 11. Human Development Index in Municipality, State and in the Brazil

<table>
<tr><th rowspan="2">Municipality</th><th rowspan="2">State</th><th colspan="2">Municipality
HDI</th><th colspan="2">State
HDI</th><th colspan="2">Brazil
HDI</th></tr>
<tr><th>1991</th><th>2000</th><th>1991</th><th>2000</th><th>1991</th><th>2000</th></tr>
<tr><td>Aracruz</td><td>ES</td><td>NA</td><td>0,772</td><td>0.690</td><td>0.765</td><td rowspan="11">0.696</td><td rowspan="11">0.766</td></tr>
<tr><td>Belo Oriente</td><td>MG</td><td>NA</td><td>0,697</td><td>0.697</td><td>0.773</td></tr>
<tr><td>Bragança Paulista</td><td rowspan="6">SP</td><td>0,763</td><td>0,820</td><td rowspan="6">0.778</td><td rowspan="6">0.820</td></tr>
<tr><td>Luís Antônio</td><td>0,717</td><td>0,795</td></tr>
<tr><td>Mogi Guaçu</td><td>0,762</td><td>0,813</td></tr>
<tr><td>Nova Campina</td><td>NA</td><td>0,709</td></tr>
<tr><td>Jacareí</td><td>0,761</td><td>0,809</td></tr>
<tr><td>Suzano</td><td>0,734</td><td>0,775</td></tr>
<tr><td>Três Barras</td><td>SC</td><td>NA</td><td>0,758</td><td>0.748</td><td>0.822</td></tr>
<tr><td>Telêmaco Borba</td><td rowspan="2">PR</td><td>0,703</td><td>0,767</td><td rowspan="2">0.711</td><td rowspan="2">0.787</td></tr>
<tr><td>Curitiba</td><td>0,798</td><td>0,856</td></tr>
</table>

Source: PNUD, 2007

Table 12. Evolution of employment and of average income in municipality in 2001-2006 period

Municipality	Total Employment						Employment in Industry						Employment in Pulp & Paper					
	2001	2002	2003	2004	2005	2006	2001	2002	2003	2004	2005	2006	2001	2002	2003	2004	2005	2006
Aracruz- ES	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1.206
Belo Oriente – MG	3.665	4.432	6.287	NA	NA	NA	NA	NA	2.436	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bragança Paulista - SP	22.465	23.976	25.068	26.620	28.366	NA	6.553	6.767	7.690	8.526	8.997	NA	NA	NA	NA	NA	NA	696
Luís Antônio - SP	4.612	4.221	4.467	2.920	4.353	NA	1.219	962	956	722	1.124	NA	NA	NA	NA	NA	NA	NA
Mogi Guaçu - SP	24.098	26.524	26.697	28.939	29.744	NA	9.221	8.752	9.264	10.444	10.767	NA	NA	NA	NA	NA	NA	1.561
Nova Campina - SP	1.059	1.235	1.592	1.519	1.924	NA	604	647	726	668	648	NA	NA	NA	NA	NA	NA	NA
Jacareí - SP	31.683	31.588	30.966	31.742	33.474	NA	11.326	10.330	9.785	10.310	11.668	NA	NA	NA	NA	NA	NA	865
Suzano - SP	29.645	32.445	34.112	36.021	38.357	NA	15.082	16.396	16.838	17.681	18.261	NA	NA	NA	NA	NA	NA	3.301
Três Barras - SC	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Telêmaco Borba - PR	10.210	10.769	12.859	13.890	14.627	15.688	3.167	3.844	4.487	5.265	5.366	5.341	1.827,00	1.763	1.744	1.753	1.700	1.713
Curitiba - PR	572.772	585.972	583.094	633.869	648.706	716.519	71.241	71.417	72.365	81.056	82.450	87.870	8.917,00	8.753	8.555	9.544	9.792	10.768

Source: IPEA, 2007; IBGE, 2007a; IBGE, 2007c

Table 12. Evolution of employment and of average income in municipality in 2001-2006 period

Municipality	Total Population						Average Income US$						Average income in industry US$					
	2001	2002	2003	2004	2005	2006	2001	2002	2003	2004	2005	2006	2001	2002	2003	2004	2005	2006
Aracruz- ES	NA	NA	NA	NA	NA	73.657	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Belo Oriente – MG	NA	NA	NA	NA	NA	21.584	425,11	286,84	341,30	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bragança Paulista - SP	127.627	130.553	133.545	136.608	139.740	143.621	295,17	203,08	297,46	354,16	441,94	NA	293,69	211,51	331,00	398,82	511,72	NA
Luís Antônio - SP	7.282	7.421	7.562	7.706	7.853	8.136	390,53	290,31	432,17	612,43	699,95	NA	868,09	634,07	950,24	1.191,92	1.178,59	NA
Mogi Guaçu - SP	126.577	129.225	131.929	134.689	137.506	141.559	377,76	252,42	361,93	427,35	546,75	NA	575,65	399,60	560,32	680,88	861,16	NA
Nova Campina - SP	7.513	7.761	8.018	8.282	8.557	8.830	243,95	188,90	277,65	358,84	450,24	NA	287,22	224,99	399,74	521,27	866,66	NA
Jacareí - SP	193.922	196.876	199.876	202.922	206.014	211.559	460,12	325,74	460,85	510,24	650,43	NA	715,24	535,91	790,62	812,60	1.006,47	NA
Suzano - SP	235.871	244.104	252.624	261.441	270.566	280.318	422,22	297,26	415,76	481,34	616,90	NA	555,92	379,22	555,29	650,38	806,56	NA
Três Barras - SC	NA	NA	NA	NA	NA	18.224	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Telêmaco Borba - PR	61.623	62.079	62.469	63.289	63.742	64.192	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Curitiba - PR	1.620.219	1.644.600	1.671.194	1.727.010	1.757.904	1.788.559	NA	NA	NA	NA	472,21	717,35	NA	NA	NA	NA	NA	722,47

Source: IPEA, 2007; IBGE, 2007a; IBGE, 2007c

It is important to describe that municipalities such as Aracruz, in the state of the Espirito Santo, and Telemaco Borba, in the state of the Parana, had a economic and social development around the pulp and paper mills. The state of Sao Paulo, for having a long history of industrial development, has the economic and social development of municipalities as Bragança Paulista, Mogi Guaçu, Jacarei and Suzano, supported by diverse industrial sectors. The municipality of Curitiba, in the state of the Paraná, for contain the capital of the state, move its economy through several industry and services sectors.

Among the 11 mills contemplated in the sample, six of them had implanted more than 40 years behind. These plants, and its respective firms, were part of the creation of the pulp and paper industry in Brazil, and some of the formation and development of municipalities, when in these regions did not have infrastructure nor people with education and technical skill necessary. In the middle of adverse conditions, communities was being formed around these mills, with great parto of the people come from other regions of Brazil, becoming the life of these people total dependant of the activities and resources of these firms. These plants, on the other hand, had that to create in the respective regions minimum conditions of life, assuming the task to construct and operate schools, hospitals, sanitation and, in some few cases, suppling of water, electric energy and communication.

It was identified through the interviews and documentation, that until middle of the 1990's, a substantial contingent of workers in these mills had the basic education only. These people, although to have acquired great experience in its work, had not dedicated themselves throughout the time to give continuity in its educational formation. It was necessary to the firms stimulate and help these people to reach the middle- and high-level education, even because the productive processes was becoming sophisticated and demanding a level of education and technical capability more complex. Currently, these mills require of its employees middle-level education as more basic formation. For such, the municipality have a considerable number of educational establishments (Table 14), including colleges and universities, and enrolments, as it happens in Aracruz, Jacarei, Telemaco Borba and Curitiba. Through the Table 20 it is possible to observe the evolution of the number of school enrollments in each municipality realized in 2000-2006 period.

Of course the mills implanted in the Sao Paulo region and with less than thirty years of age, present a context of employment and qualification more structuralized. However, in function of its specific type of productive process, all the mills always had difficulty to employ specialized workers, assuming the task of training. This context of implantation and expansion of these mills, accomplish the firms to keep its employees, being become a characteristic of the pulp and paper sectors the low turnover of employees. From the last years, this characteristic are modifying, as much in function of technical-organizational changes in the mills, as by the growth of work opportunities for the specialized professionals, mainly in the areas as chemistry, electronics and electricity.

Table 13. Evolution of industrial labour productivity in municipality in the 2001-2006 period

Municipality	State	2001	2002	2003	2004	2005	2006	Average Annual Rate of Growth
Aracruz	ES	NA	NA	NA	NA	138.65	NA	NA
Belo Oriente	MG	NA	NA	NA	NA	NA	NA	NA
Bragança Paulista	SP	NA	11,581.36	13,408.43	16,518.83	22,444.15	NA	24.68
Luís Antônio	SP	NA	74,465.51	100,279.38	160,592.87	115,350.77	NA	15.71
Mogi Guaçu	SP	NA	14,726.72	21,936.55	2,344.23	25,401.39	NA	19.93
Nova Campina	SP	NA	11,437.33	12,652.04	17,265.52	21,159.20	NA	22.76
Jacareí	SP	NA	33,957.32	4,859.90	54,596.95	52,249.36	NA	15.45
Suzano	SP	NA	24,331.09	35,108.07	43,558.02	49,931.00	NA	27.08
Três Barras	SC	NA	NA	NA	NA	NA	NA	NA
Telêmaco Borba	PR	69,986.83	48,735.83	68,059.48	72,839.74	88,453.82	89,306.70	5.00
Curitiba	PR	28,088.35	17,959.37	29,850.56	37,394.60	46,454.48	45,302.90	10.03

Source: Derived from the empirical study

Table 14. Evolution of the number of educational establishments in the municipalities (2000-2006)

Municipality	Elementary and Middle School							High School							Universities						
	2000	2001	2002	2003	2004	2005	2006	2000	2001	2002	2003	2004	2005	2006	2000	2001	2002	2003	2004	2005	2006
Aracruz- ES	50	51	49	51	50	48	46	9	9	9	9	9	9	10	1	1	1	2	2	2	2
Belo Oriente – MG	9	8	9	8	10	10	10	2	2	2	2	2	2	2	0	0	0	0	0	0	0
Bragança Paulista - SP	71	73	73	74	73	76	86	17	16	15	16	17	17	21	2	2	2	2	2	NA	NA
Luís Antônio - SP	2	3	3	3	3	4	4	2	2	2	2	1	1	1	0	0	0	0	0	0	0
Mogi Guaçu - SP	41	42	44	45	48	49	66	16	18	19	19	24	25	26	1	1	1	1	2	NA	NA
Nova Campina - SP	5	4	4	4	4	4	6	1	1	1	1	2	2	2	0	0	0	0	0	0	0
Jacareí - SP	64	66	68	71	72	75	76	30	34	34	30	32	32	31	3	3	3	4	5	NA	NA
Suzano - SP	71	74	79	71	81	86	140	24	24	25	27	30	32	32	1	1	1	1	1	NA	NA
Três Barras - SC	9	9	9	9	9	9	9	3	4	3	3	3	3	3	0	0	0	0	0	0	0
Telêmaco Borba - PR	42	43	44	44	45	45	43	8	8	8	10	11	12	12	1	1	1	1	1	1	1
Curitiba - PR	402	407	399	410	414	415	425	146	158	168	169	164	167	178	27	28	34	40	41	NA	NA

Source: INEP, 2007

Table 15. Evolution of the number of enrolments in educational establishments in the municipalities (2000-2006)

Municipality	Elementary and Middle School							High School							Universities						
	2000	2001	2002	2003	2004	2005	2006	2000	2001	2002	2003	2004	2005	2006	2000	2001	2002	2003	2004	2005	2006
Aracruz- ES	15,438	15,167	14,905	14,145	14,754	14,754	14,205	4,679	5,050	4,930	5,491	5,022	4,677	4,481	1,083	1,273	1,374	1,645	1,651	NA	NA
Belo Oriente – MG	4,310	4,284	4,549	4,425	4,067	4,098	4,374	1,237	1,141	1,036	1,123	1,057	965	874	0	0		0	87	103	NA
Bragança Paulista - SP	20,878	20,827	21,023	20,769	20,903	20,921	21,068	6,713	6,140	6,128	6,191	6,230	5,968	5,886	7,237	7,817	7,577	6,421	NA	NA	NA
Luís Antônio - SP	1,396	1,501	1,563	1,614	1,697	1,733	1,804	481	384	383	390	423	424	405	0	0	0	0	0	0	0
Mogi Guaçu - SP	21,320	20,810	20,541	19,860	19,615	19,637	19,742	7,793	7,496	7,466	7,732	7,739	7,212	6,608	625	716	793	873	891	NA	NA
Nova Campina - SP	1,547	1,603	1,581	1,688	1,753	1,748	1,834	293	350	400	404	389	325	283	0	0	0	0	0	0	0
Jacareí - SP	32,438	31,664	31,300	30,634	30,721	30,873	30,915	12,475	11,741	11,812	11,339	10,952	10,168	9,167	1,322	1,681	1,515	2,075	7,081	NA	NA
Suzano - SP	44,103	43,574	43,686	43,193	42,919	44,615	49,553	13,948	13,539	14,881	15,770	15,181	13,752	12,720	135	318	393	713	921	NA	NA
Três Barras - SC	3,619	3,797	3,643	3,556	3,740	3,847	3,836	701	911	976	1,078	1,024	815	784	0	0	0	0	0	0	0
Telêmaco Borba - PR	10,661	10,504	10,084	10,359	10,375	10,397	11,059	3,206	2,957	2,691	2,880	2,963	2,852	2,924	152	383	695	783	955	1,074	NA
Curitiba - PR	250,378	257,015	255,323	256,610	255,116	251,901	250,028	96,158	9,205	87,204	86,854	83,149	82,292	87,059	73,576	79,470	89,759	102,526	104,672	108,866	NA

Source: INEP, 2007

7. Conclusions

Drawing on a combination between qualitative and quantitative evidence the study found a positive association (not causality) between efforts on innovative capability building and improvement on different types of process and environment performance indicators in the researched pulp and paper firms. Improvements on these indicators were associated with innovation efforts to achieve operational, technical and economic performance improvement. The evidence shows that environment performance improvement was associated with innovative capability building. As a result, the findings show that the paths by which latecomers firms can achieve international leadership in process-intensive (and natural resources related industries) by building innovative capability beyond catching-up to overtake early innovators. On the basis of the building of such innovative capabilities firms can improve operational and environment performance indicators. Thus, it is not possible to design corporate strategies and government policies for operational and, mainly, environment performance improvement without understanding and tackling the issue of firm-level innovative capability building, especially the nature, direction and rate of innovative capability building within firms. Otherwise, issues like ‘corporate social responsibility’ and ‘environmental sustainability’ risk being confined to opportunistic rhetoric.

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